Numerical modeling of the ballistic behavior of a needlepunched nonwoven

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Nonwoven fabrics made of high-performance polymeric fibers have been successfully used for protection against small fragment impact [1]. In this work, the ballistic performance of a needlepunched nonwoven made of ultrahigh molecular weight polyethylene (UHMWPE) fibers was studied by means of numerical simulations based on a physically-based constitutive model [2, 3]. This constitutive model encompasses the main deformation and failure mechanisms (fiber uncurling, re-orientation, fiber sliding and pull-out) [4]. Subsequent simulations were able to reproduce the behavior of the material under impoact loading, including anisotropy, damage localization as well as the ballistic limit of pristine and predeformed specimens. The simulation results helped to understand the role played by fiber connectivity and the different mechanisms during impact [2]. This information can be extremely valuable to improve the ballistic performance of new nonwoven fabrics.

[1] Ipson, Thomas W. ; Wittrock, Edward P.v (1966) Response of Non-Woven Synthetic Fiber Textiles to Ballistic Impact . Technical report, Denver Research Inst.

[2] F. Martínez-Hergueta, A. Ridruejo, C. González, J. Llorca (2017) Numerical simulation of the ballistic response of needle-punched nonwoven fabrics. International Journal of Solids and Structures, 106, pp. 56-67

[3] F. Martínez-Hergueta, A. Ridruejo, C. González, J. Llorca (2016). A multiscale micromechanical model of needlepunched nonwoven fabrics. International Journal of Solids and Structures, 96, pp. 81-91.

[4] F. Martínez-Hergueta, A. Ridruejo, C. González, J. LLorca (2015) Deformation and energy dissipation mechanisms of needle-punched nonwoven fabrics: A multiscale experimental analysis. International Journal of Solids and Structures, 64, pp. 120-131